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Research Article

Acceptable Level of Acceptance and the Affecting Factors: What Is the Acceptable Public Acceptance of Building a Nuclear Power Plant

Drajat Tri Kartono,[1] **Sri Hastjarjo**,[1] **Sajidan**,[1] **Bob Soelaiman Effendi**,[2] **Dhita Karunia Ashari**,[2] **Purbayakti Kusuma Wijayanto**,[3] **Zahra Nadhila Saraswati**,[2] **and Alexander Yonathan Christy**[1]

[1]*Sebelas Maret University, Surakarta, Indonesia*
[2]*PT. Thorcon Power Indonesia, Jakarta, Indonesia*
[3]*Slamet Riyadi University, Surakarta, Indonesia*

Correspondence should be addressed to Sri Hastjarjo; sri.hastjarjo@staff.uns.ac.id

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This research determines the Acceptable Level of Acceptance (ALA) based on the countries with active Nuclear Power Plant (NPP). The ALA is a particular value of public acceptance of NPP, indicating public support and participation in the program. If the public acceptance level is lower than the ALA, then the probability of public resistance against the program is relatively high and would harm the NPP. There is no correlation between the number of populations. This research uses four categories to classify public acceptance: (1) low, (2) moderate, (3) high, and (4) very high. Based on these categories, this research suggests that the moderate ALA is 27.5% of the acceptance level.

1. Introduction

The modern technology of nuclear power plants energy has overcome the problem of public resistance against nuclear energy. However, this solution does not lead to instant public acceptance. There have been numerous studies on countries' public acceptance levels for nuclear power plants. The results on average in several countries are as follows: Slovenia at 15.70%, Japan at 21.04%, Germany at 21.09%, Finland at 29.09%, Brazil at 31%, China at 42%, France at 50.87%, the United States at 52%, and the United Arab Emirate 63% [1–5]. There is currently no available literature on standards that define an acceptable level of acceptance (ALA) based on the countries with active nuclear power plant (NPP).

According to [6], a research company, the demand for electrical energy in 1985 was 2,028 kWh and grew until 2019 to 3,501 kWh. A government must supply enough energy for the citizen to avoid energy shortages. On the other hand, traditional power plants produce waste, which is harmful to the environment. The power plants that generate electricity from coal, oil, and natural gas have the highest carbon emission. Most of their byproduct is CO_2, which causes the greenhouse effect of global climate change [7]. The energy shortage and climate change are two reasons to use nuclear energy because nuclear power plants produce high energy with low carbon emissions [3].

There are two main reasons for public resistance against nuclear energy: (1) the traditional nuclear power plant produces radioactive waste and (2) safety factors related to nuclear disasters. The public generally has limited awareness of NPP and common essential knowledge to understand that nuclear energy produces low emissions and has high efficiency [8]. This condition leads to many considerable setbacks against the NPP establishment. Sugiawan and Managi [9] mentioned that trust in the authorities is critical to

enhancing public acceptance in Indonesia. In China, the government promotes NPP as the solution to climate change and energy shortages [10]. The Three Mile Island, Pennsylvania, in 1979, Chernobyl in 1986, and Fukushima in 2011 affected public acceptance of NPP for a long duration [11]. After Chernobyl, local activism, which had been strengthened with the support of Greenpeace, inquired about the safety of plants and their effects on health and the environment around them. A systematic Brazilian Association of Nuclear Energy campaign brought scientists and technicians from the field. It discredited Greenpeace and the whole movement, ending the debate on risks and nuclear contamination [12]. From then on, scientists engaged in the topic could not obtain research funds to develop studies on these subjects.

Public acceptance varies due to personal, psychological, and contextual factors [13]. So then, a standard is needed to determine an acceptable level of public acceptance for nuclear power plant development. Not only that, but there is also a relationship between public acceptance and rejection of the risk of these activities. However, sometimes people have a wrong perception of risk. In connection with this issue, rejection correlates with the real (actual) risk and the perception of risk that is sometimes inversely related to the actual risk. ALA is determined in this study to describe conditions that lead to public support and participation in nuclear power plants. Meanwhile, to see the level of risk to a state of acceptance, several risk levels can be accepted by the community or called acceptable level of risk (ALR).

This research defines ALA to describe the condition that leads to public support and participation toward the NPP establishment based on the public acceptance data. IPSOS [1] mentions that the world average public acceptance level of NPP is 39.32%. These data suggest that the NPP program is ongoing even if more than half of the population does not support the program. The variable predicted to have a relationship with the public acceptance level of nuclear power plants in a country is the total population. The population size is related to electricity demands. The research study in Malaysia conducted by Jifri et al. [14] showed that gross domestic product (GDP), population, and maximum temperature are affected by the electrical load demand pattern based on their Pearson correlations. Also, electricity demand is increasing rapidly due to the ever-increasing population and technological revolution [15].

There is a variation in the world average public acceptance level mentioned in many research publications: 21.91% [3], 51.57% [4], 45.78% [5], and so on. Public acceptance is commonly measured in public opinion polls, but Aitken [16] argued that using representative opinion poll data to indicate technology acceptance paints a skewed picture. However, other research studies measured public acceptance using the ordered probit model [17] and the theoretical predictive models [18]. Zainudin and Ishak [17] used the ordered probit model for probit analysis generalization to the case of more than two outcomes of an ordinal-dependent variable. For theoretical predictive models, there are some aggregate levels (e.g., modal split models) or disaggregate level (e.g., discrete choice models) methods to predict the quantitative changes in behavior [18]. Moreover, no synthesis of the available literature on this topic is currently available.

The purposes of this research are to determine the ALA for NPP establishment and to analyze its determinants. The ALA is obtained by clustering the data of world public acceptance of NPP from various sources into four categories: (1) low, (2) intermediate, (3) high, and (4) very high. This research examined the correlation between public acceptance of a state to the number of populations and its gross domestic product (GDP). The number of people is linearly dependent on the demand for electrical energy in a particular state. The GDP represents the quality of the economy; it describes the national investment in education, public services, power plants, and so on. This paper structure is as follows: (1) Section 2 shows the methodology and introduces the analysis; (2) Section 3 discusses the stability of the ALA; and (3) Section 4 gives conclusions about this study.

2. Materials and Methods

The history of nuclear power plants begins after the end of WW2. The world realized that nuclear is a powerful source of energy. Instead of using it as a weapon, people can convert the energy into electricity using a power plant. Even though many believe that nuclear is a powerful energy source, the Hiroshima and Nagasaki accident still leave fear in people, leading to resistance toward NPP.

Aritonang et al. [19] have researched recommendations for government to increase public acceptance of nuclear power plant (NPP) establishment in Jepara, Central Java, Indonesia. Their report identified that the residents' reasons for rejecting NPP establishment include (1) fear of issues (radiation and disaster); (2) fear of losing livelihood and being threatened by relocation; (3) human resources are not yet professional; (4) nongovernmental organizations (NGOs) as stakeholders that affect the community; (5) distrust towards national and local government; and (6) insurance and compensation, metaphysical costs, and so on.

Cited to the newspaper Lusakatimes [20], the Chongwe residents have rejected the planned construction of a Nuclear Science and Technology Plant in the area. Based on the newspaper, the reason for the rejection is due to the fear of accident, disaster, radiation, and nuclear weapons because they do not have the means or the capacity to evacuate the entire city for a prolonged time if such terrible things happen. So, if the research and development of nuclear should be constructed, the government should take such facilities very far from human settlements where a disaster's impact will be minimal.

Previous studies have shown at least two main reasons behind the strong opposition to nuclear energy. First, nuclear power is considered a high-risk technology usually associated with potential harm from radioactivity, nuclear accidents, or nuclear weapons [21, 22]. Second, many nuclear decision-making processes only focus on technological and economic aspects, ignoring the importance of public involvement, ultimately leading to public distrust [23].

ALA is determined in this research because there is currently no available literature on standards that define an Acceptable Level of Acceptance (ALA) based on the countries with active Nuclear Power Plant (NPP). The Acceptable Level of Acceptance is the level at which the perception of public acceptance toward the Nuclear Power Plant Program is considered valid to determine people's participation (or Support) in the program's operation. This conceptualization of ALA is based on the concept of public acceptance, which is defined as the community member perception behavior which provides support (supportive) to the technology use that can be manifested in various forms of support ranging from passive approval (not rejecting) to initiatives and dynamic behavior in the use of technology [24]. Many countries have low public acceptance but still build and operate nuclear power plants, which shows that ALA is very important. Through the valid standards specified in the ALA, it is hoped that the government and its stakeholders will pay more attention to public acceptance in planning the development of nuclear power plants, not only to fulfill normative requirements.

A systematic literature review and meta-analysis on the perception of public acceptance toward the Nuclear Power Plant Program was conducted to define an Acceptable Level of Acceptance. ALA aims to classify public acceptance as (1) low, (2) moderate, (3) high, and (4) very high. To ensure the accessibility of the literature in this work, the literature focuses on journals, reports, conference proceedings, and articles. The data were collected from various works of literature, such as reports and journals. It is interesting to note that all the literatures have the same data collection method for public opinion polls. However, they also differ in the range of research locations, polling year, number of respondents, and response scales. The differences in the public opinion polls methodology from the literature used in this study are as follows.

No references contained the state acceptance levels of Armenia, Iran, North Korea, Pakistan, and Ukraine, so this study excluded these five countries from the population of countries with active nuclear power plants. Based on the literature in Table 1, public acceptance data from various countries are shown in Table 2.

The country grouping is done by considering the skewness value obtained after calculating the mean percentage of public acceptance in 28 countries. Based on the mean value, a standard curve is made to determine the ALA and define the uncategorized areas of acceptance (UAA) due to the world's unexisting situation. Extreme examples of this case were Slovenia, with the lowest public acceptance level, and the United Arab Emirates, with the highest public acceptance level. Furthermore, the data in Table 2 will be classified according to countries with active nuclear power plants into the following four categories: low, medium, high, and very high public acceptance levels. The variable predicted to have a relationship with the public acceptance level of nuclear power plants in a country is the population and gross domestic product. The population size is related to electricity demands. The high population of a country leads to a higher level of electricity consumption. Countries with high electricity needs are predicted to have societies open to new energy sources. It initiates the presumption that the population in a country affects the public acceptance level of nuclear power plants in that country.

A country's economic condition is also predicted to be related to the public acceptance of nuclear power plant development. Hirsh and Koomey [26] found that the relationship between electricity consumption and gross domestic product (GDP) in the United States, started in the early 1970s up to 2013, has strongly correlated with the stable linear relationship between gross domestic product (GDP) and electricity consumption over long periods. Electricity consumption growth has been stemming from the increase in economic activity. In this case, establishing a nuclear power plant includes obtaining radioactive elements, research, development, supervision, waste treatment, safety assurance, and so on. This series of activities certainly requires a large budget. If a country has low income, the public can have other priorities than nuclear power plants. On the other hand, the public can trust in accepting the construction of a nuclear power plant if there is already an appropriate budget for these activities of a certain percentage of the total state income. The amount of a country's income can be described using the amount of GDP (gross domestic product), so this research has a presumption that GDP influences public acceptance in a country. Other indicators, including historical, environmental, and geographical circumstances, were not considered because it is related to nuclear disasters. Countries that have been through the disaster until now are still operating nuclear power plants.

The correlation between the GDP and the number of populations to the acceptance level of the corresponding state was analyzed using meta-analysis, including a three-dimensional plot, correlation test, and ANOVA. A meta-analysis is a statistical method of combining results from different studies to weigh and compare and identify patterns, disagreements, or relationships that appear in the context of multiple studies on the same topic [27] meta.

3. Results and Discussion

3.1. Country Grouping Based on the Public Acceptance Level of NPP. With the meta-analysis method, each primary study is abstracted and coded, and the results are then turned into a standardized metric for calculating the overall effect size [28]. To undertake a meta-analysis, however, the included studies must share statistical metrics (effect size) for comparing their results. Table 2 displays the public acceptance of nuclear energy used in various countries with active nuclear power plants. This value shows what percentage of a sample of citizens of a country agreed with nuclear energy use for electricity generation. Surveys taken as reference material may use different samples and times so that a country can have more than one level of acceptance. This study employed the mean value of data from various reference sources to represent the overall acceptance level in a country. Table 3 shows the mean values of public acceptance in various countries.

Table 3 shows the average value of public acceptance in 28 countries from data from several sources and different

Table 1: The differences of public opinion polls methodology on public acceptance literature.

Author	Year	Area coverage	Number of respondents	Response scale
(1) IPSOS	2011	24 countries	18,787	(a) Strongly support (b) Somewhat support (c) Somewhat oppose (d) Strongly oppose
(2) Win-Gallup international	2011	47 countries	34,000	(a) Favorable (b) Unfavorable (c) Net favor (d) No response
(3) Wang and Kim	2018	47 countries	1000 per country	(a) Accept (b) No preference (c) Refuse
(4) World nuclear association	2021	±50 countries	750–1,000	Various response scales (a) Positive-negative/favor-against (b) Favor of building new nuclear power plants, favor of continuing to run existing ones, and wanting to phase out (c) Favor of building new nuclear power plants, favor of continuing to run existing ones, wanting to phase out nuclear power, and undecided

Table 2: A country's public acceptance level for nuclear power plants.

Countries	The public acceptance level of nuclear power plants from various reference sources (%)				
	IPSOS [6]	Wang and Kim [3]	Win-Gallup international [4]	World nuclear association [5]	Other sources
(1) Argentina	28.00	—	—	—	—
(2) Belarus	—	—	—	28.30 (2005); 53.50 (2012)	Grusha et al. [25]: 65.10
(3) Belgium	40.00	12.00	—	80.00 (2017); 83.00 (2019)	—
(4) Brazil	31.00	—	—	—	—
(5) Bulgaria	—	33.00	68.00; 62.00	—	—
(6) Canada	37.00	—	—	—	—
(7) China	42.00	—	—	—	—
(8) Czech Republic	—	26.50	63.00; 61.00	—	—
(9) Finland	24.00	24.00	—	28.00 (2001); 32.00 (2004); 18.00 (2007) 18.00 (2010); 25.00 (2013); 26.00 (2016)	Murakami and Anbumozhi [2]: 33.00 (2010); 51.00 (2012); 41.00 (2014)
(10) France	33.00	12.80	66.00; 58.00	77.00 (1998); 74.00 (2005); 48.00 (2011) 16.00 (2012); 72.00 (2014)	—
(11) Germany	—	7.70	34.00; 26.00	—	—
(12) Hungary	41.00	27.80	—	—	—
(13) India	61.00	—	—	—	—
(14) Japan	42.00	—	—	—	Murakami and Anbumozhi [2]: 20.40 (2010); 10.00 (2011); 13.90 (2012); 18.90 (2013)
(15) Mexico	19.00	—	—	—	—
(16) Netherland	—	28.40	51.00; 44.00	—	—
(17) Romania	—	26.20	—	—	—
(18) Russia	38.00	—	—	—	—
(19) Slovakia	—	24.30	—	—	—
(20) Slovenia	—	15.70	—	—	—
(21) South Africa	40.00	—	—	—	—
(22) Spain	40.00	9.70	39.00; 41.00	—	—
(23) Sweden	49.00	28.70	—	27.00 (2004); 33.00 (2011); 35.00 (2019)	—
(24) Switzerland	—	—	40.00; 47.00	—	—
(25) South Korea	39.00	—	—	—	—
(26) United Arab Emirate	42.00	—	—	68.00 (2013); 79.00 (2017)	—
(27) United Kingdoms	49.00	29.90	—	23.00 (2019)	—
(28) United States	52.00	—	—	—	—

Table 3: The mean values of public acceptance in various countries.

Countries	Mean (%)
(1) Argentina	28.00
(2) Belarus	48.90
(3) Belgium	53.75
(4) Brazil	31.00
(5) Bulgaria	54.33
(6) Canada	37.00
(7) China	42.00
(8) Czech Republic	50.17
(9) Finland	29.09
(10) France	50.87
(11) Germany	21.09
(12) Hungary	34.40
(13) India	61.00
(14) Japan	21.04
(15) Mexico	19.00
(16) Netherlands	41.13
(17) Romania	26.20
(18) Russia	38.00
(19) Slovakia	24.30
(20) Slovenia	15.70
(21) South Africa	40.00
(22) Spain	32.43
(23) Sweden	34.54
(24) Switzerland	43.50
(25) South Korea	39.00
(26) United Arab Emirate	63.00
(27) United Kingdom	33.97
(28) United States of America	52.00
Mean (%)	38.05
Skewness	0.18

years. Based on the public acceptance data, the overall average value is 38.05, and the skewness value is 0.18. The data skewness close to the value 0 signifies that the mean of the data was close to the mean. Thus, the medium category representing the category in the middle of the entire dataset was made to contain a mean value.

(a) The low category starts at 0% and contains the lowest data value. The maximum score of this category is less than the mean.

(b) The medium category contains the mean score, where the minimum score is less than the mean, and the highest score is more than the mean.

(c) The high category has a minimum value that is more than the mean and a maximum value less than the highest data.

(d) The low, medium, and high categories have the same interval length.

(e) The very high category must contain the highest data; the maximum value is less than the domain limit (100%).

The mean public acceptance level of nuclear power plants in Table 3 was 38.05%, with the domains ranging from 0% to 100%. The lowest known data acceptance level was 15.7% (Slovenia), while the highest known data were 63% (United Arab Emirates). Grouping was made with the following rules. From the five rules, a data interval of 20% could be selected for the first three categories to obtain the following:

(a) The low category contains data ranging from 0% to 20%

(b) The medium category contains data at intervals of 20% to 40%

(c) The high category contains data at 40% to 60%

(d) The rest, namely, the 60% to 100% interval, falls into the very high category

Figure 1 shows the grouping of states based on Table 3 using predefined rules.

The standard curve given above is a centralization analysis based on a country's grouping of public acceptance percentage of nuclear power plants worldwide, as shown in Figure 1. The distribution is constructed with a minimum value of 16, and the maximum value of 63 tends to leave skewness. That range and number of samples provide a mean of 38.05% and a standard deviation (SD) of 12.79%. The acceptable level of acceptance (ALA) determines the best position on +2SD. However, +1SD is still considered suitable to be trusted because it is still close to the normal distribution. Based on the standard curve, ALA is the level of NPP public acceptance, around 51.5% to 63%. There are also uncategorized areas of acceptance (UAA) in the standard curve due to the world's unexisting situation. Those are under −2SD (below 16% to 0%) and above +2SD (higher than 63% to 100%).

The mean public acceptance level of nuclear power plants in all countries with active nuclear power plants was 38.05%. It denotes having 39% of the public supported nuclear energy use for electricity generation, which was already included in the above-average category, despite more than 50% of greed. It shows that a country needs to compare its public acceptance level with other countries to avoid wrong interpretations. For example, a survey may consider the public acceptance level in a country of 40% as a low value simply because more citizens disagree even though the value is already above the average public acceptance level in the world, according to various reference sources in Table 2.

Apart from comparing the public acceptance level with other countries, things that need to be considered are the variables affecting the acceptance level. Table 2 shows that surveys conducted at different times may produce different results.

3.2. ALA Stability-Based PDB and Population Partial Variation. The variable predicted to have a relationship with the public acceptance level of nuclear power plants in a country is the population and GDP (gross domestic product). Table 4 shows population and GDP data from the latest World Bank data available on its website. The skewness values in the two datasets were 3.28 and 4.51, respectively. These two values indicate that the mean of the two datasets was much larger than the median. It could happen because

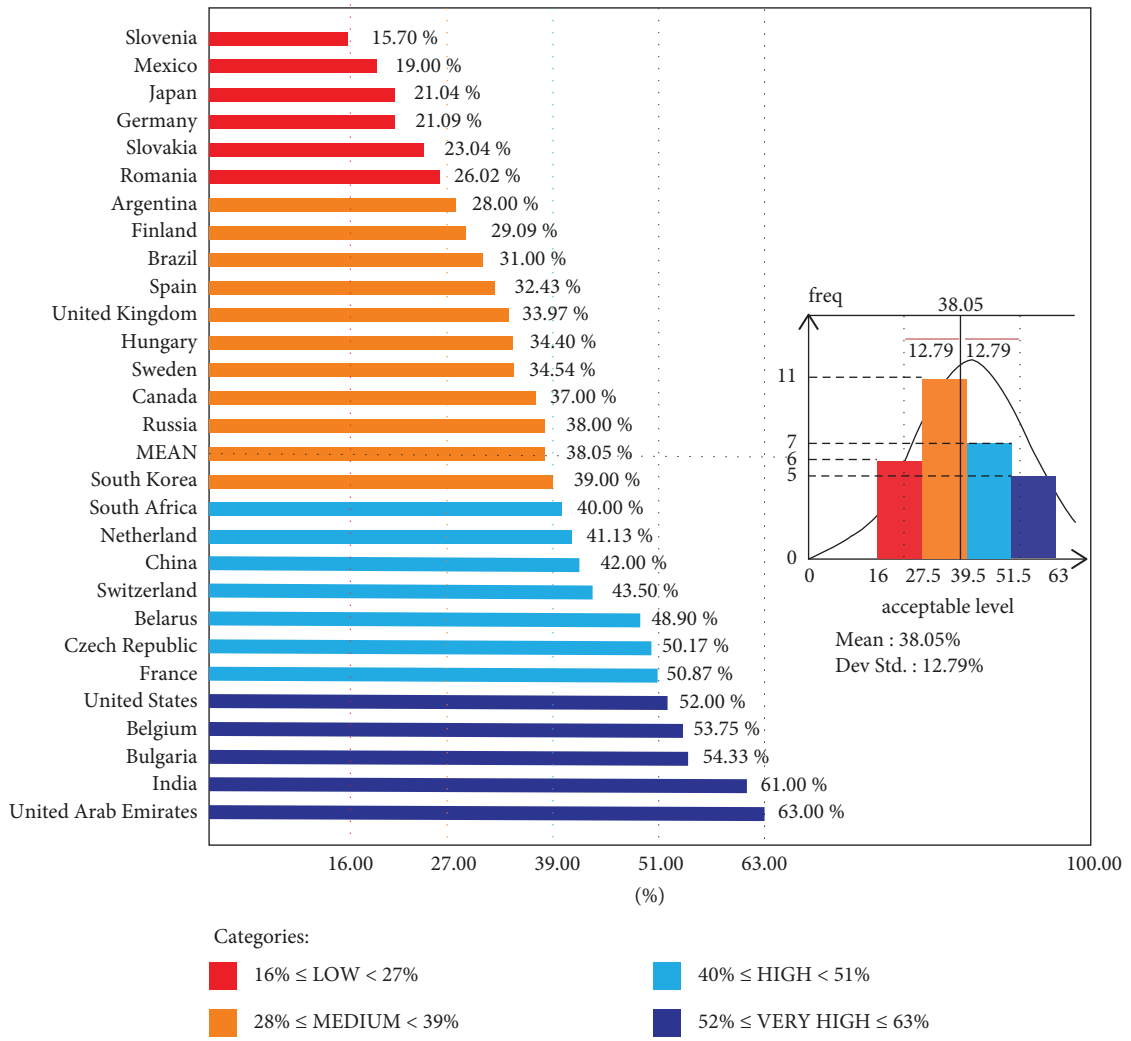

Figure 1: State grouping based on the public acceptance level of nuclear power plants.

there were datasets with a value much more significant than most of them. From population data, China (1.398 billion inhabitants) and India (1.366 billion inhabitants) were far more than other countries, even when compared to the USA (328 million inhabitants) as the country with the third-largest population in the world. The size of these data difference affected the mean value calculation, so it was outside the middle of the actual data. Likewise, with GDP data, the USA's GDP (21.43 trillion USD) was far above other countries' GDP.

The statistical conditions in Table 4 made the previous grouping rules less suitable because the mean of the data was outside the middle of the whole data, which the medium category should represent. The medium category in Table 4 needs to contain the median, not the mean. Another thing to note is that the data domain in Table 2 differed from the data in Table 4 because the population and GDP data do not have an upper limit. Apart from that, the grouping rules for these data were the same as before. The chosen interval distance for the low, medium, and high categories in the population data was 40 million, while the GDP data were 650 billion USD.

Figure 2 displays the grouping results in Table 4 according to the rules already mentioned. The horizontal axis in Figure 2 represents the total population, while the vertical axis signifies GDP. Each country was defined as a point at specific coordinates. The dots were colored according to the category grouping of countries based on the public acceptance level in Figure 1. There were outliers for the population data, namely, China and India, while the outliers for the GDP data were the USA. The points representing the countries considered to be data outliers were not at the actual coordinates in Figure 2. It was made so that the coordinates of other issues could be observed in more detail and analyzed better.

Figure 2 was analyzed based on the coordinates of the point representing the grouping of countries based on the population and GDP and the color signifying the group of countries based on the public acceptance level. There are two areas with different scales, the yellow area with an aspect ratio of 25 : 1 and the grey area, which is not scaled. The yellow area has an aspect ratio of 25 : 1 per unit area, which means that 1 unit area contains 1 point on the X-axis and is scaled to 25 points on the Y-axis. Meanwhile, the grey area contains a data outlier, so the grey area cannot be scaled.

Table 4: Total population and GDP of countries with active NPPs.

Countries	Demographic data		Economic data	
	Total population (million)	Category	GDP (billion USD)	Category
Argentina	44.94	Medium	445.40	Low
Belarus	9.47	Low	63.08	Low
Belgium	11.46	Low	533.10	Low
Brazil	211.00	Very high	1840.00	High
Bulgaria	7.00	Low	68.56	Low
Canada	37.59	Medium	1736.00	High
China	1398.00	Very high	1434.00	High
Czech Republic	10.56	Low	250.70	Low
Finland	5.52	Low	269.30	Low
France	67.06	Medium	2716.00	Very high
Germany	83.02	High	3861.00	Very high
Hungary	9.77	Low	163.50	Low
India	1366.00	Very high	2869.00	Very high
Japan	126.30	Very high	5082.00	Very high
Mexico	127.60	Very high	1269.00	Medium
Netherlands	17.28	Low	907.10	Medium
Romania	19.41	Low	250.10	Low
Russia	144.40	Very high	1700.00	High
Slovakia	5.45	Low	105.10	Low
Slovenia	2.01	Low	54.17	Low
South Africa	58.56	Medium	351.40	Low
Spain	46.94	Medium	1393.00	High
Sweden	10.23	Low	530.90	Low
Switzerland	8.55	Low	703.10	Medium
South Korea	51.71	Medium	1647.00	High
United Arab Emirate	34.27	Medium	793.00	Medium
United Kingdom	55.98	Medium	2830.00	Very high
United States	328.20	Very high	21430.00	Very high
Mean	153.51		1974.84	
Median	41.27		850.05	
Skewness	3.28		4.52	

This analysis was only geometric, so the relationship between variables could only be seen from their positions on the graph. Statistical analysis was carried out in the next section by performing a correlation test. Four results can be summarized in Figure 2.

(a) Countries with a "relatively" high population and a "relatively" high GDP also had societies that tended to be more open to nuclear energy use. It could be seen from the points considered outliers in the blue area. All three countries had above-average acceptance levels.

(b) Countries with a "relatively" high population but relatively "low" GDP tended to have a low public acceptance level. It could be observed in Mexico, Russia, and Brazil. The three countries fell into the high category based on GDP data but were still below the overall mean.

(c) Countries with "relatively" high GDP but a "relatively" low population size tended to have lower public acceptance levels than the first result but higher than the second result. It could be observed in Japan, the UK, France, and Germany.

(d) Countries with "relatively" low population numbers and GDP had very diverse public acceptance levels. Extreme examples of this case were Slovenia, with the lowest public acceptance level, and the United Arab Emirates, with the highest public acceptance level.

Relatively high or low terms for the four results obtained compared the data with the mean values in Table 4. It denotes that a country with a relatively low GDP did not mean it was in a low category in Figure 2.

The population number cannot stand alone as a factor influencing the public to receive nuclear energy. Countries with a high population but a low GDP tend to have low public acceptance levels. Without proper literacy and communication, rejection in a country with a high population is difficult to contain and has the potential for excellent resistance. Conversely, a high GDP alone does not guarantee that society is open to nuclear energy. If the community considers that the electricity supply can still be fulfilled from other energy sources, the community does not need a nuclear power plant. Thus, the interpretation of Figure 2 is that combining a high population with a high GDP is necessary to produce a public with a high acceptance of nuclear energy use.

3.3. ALA Stability-Based Population and GDP-Related Variation. The data comparison analysis on the public

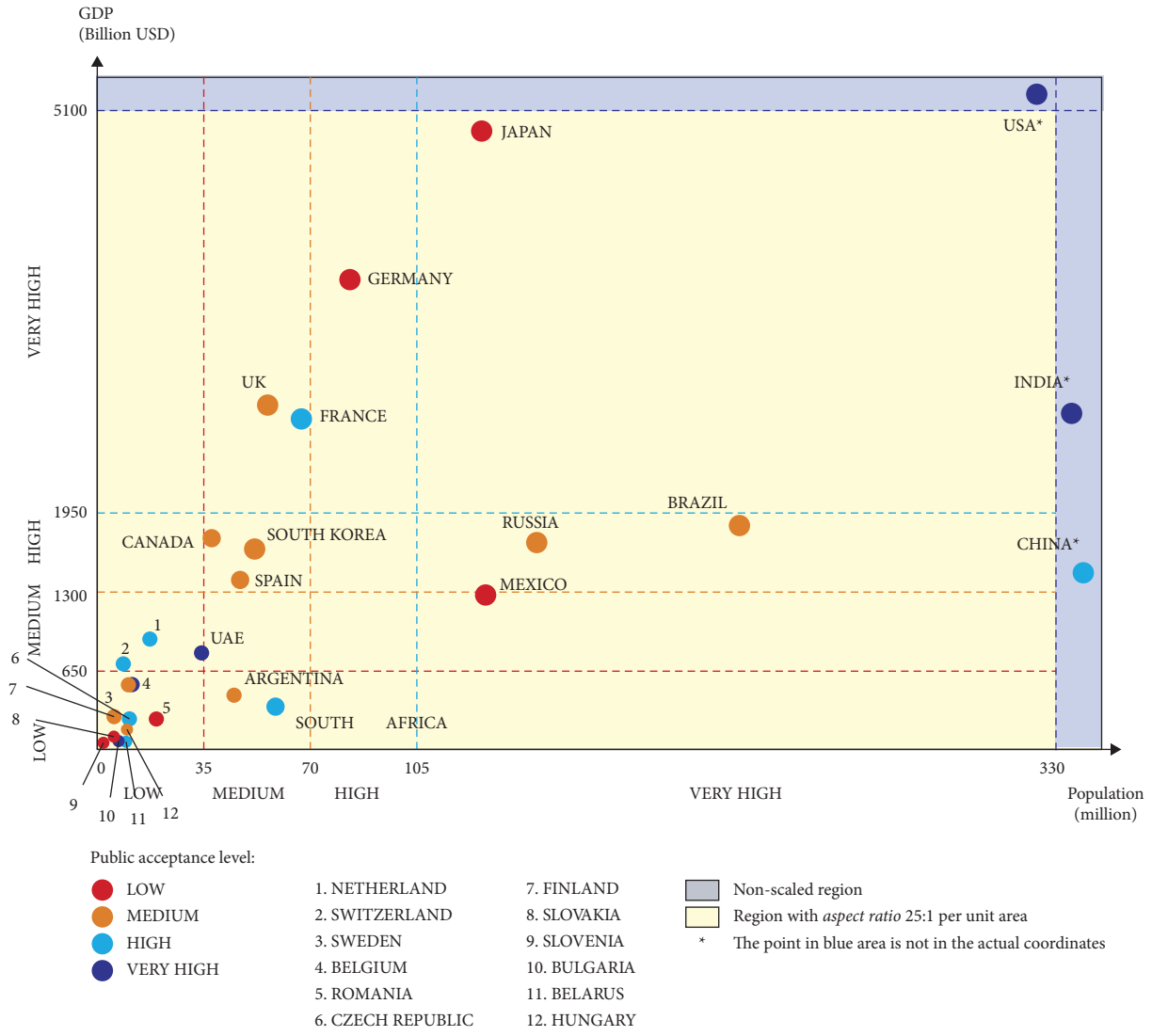

Figure 2: Classification of countries with active nuclear power plants based on population and GDP.

acceptance level based on population and GDP in the previous section has only been done geometrically. From a statistical point of view, testing is needed to determine the proper relationship between the variables influencing the public acceptance level.

Tests were carried out using the mean parameter as a comparison, so that the data mean being tested should represent the data well. Information is said to have a mean that represents the data well if it has a data distribution close to the normal distribution. The following investigated whether the data on the public acceptance level, population data (without data outliers), and GDP (without data outliers) for nuclear could be considered close to a normal distribution by the Kolmogorov–Smirnov test. Testing on the data on population numbers and GDP deliberately omitted data outliers in the test because, in Table 4, the overall data's mean was not representative, with most of the information being far below this value. The results of testing the three datasets are revealed in Table 5.

Table 5 shows that the p value of the normality test results for the three data was higher than 0.05. A 5% or 0.05 is an error tolerance standard commonly used in statistical testing. These results indicate that the data on the public acceptance level, population (without outliers), and GDP (without outliers) could be considered close to the normal distribution. Thus, the mean was considered representative for use in further testing.

Furthermore, a correlation test was conducted by calculating the Pearson correlation coefficient from the three data to determine which variables affected the public acceptance level. Variables influencing each other had a Pearson correlation coefficient marked with an asterisk if they were considered to correlate with an error tolerance of 5% and marked with two asterisks if they were supposed to correlate with an error tolerance of 1%. If the coefficient was not marked with an asterisk, then the variable pair was considered not to have a significant correlation. The results are shown in Table 6.

Table 5: The calculation results of the normality test for data on acceptance levels, total population, and GDP.

Calculated value	Acceptance level	Total population	GDP
Total data	28	26	27
Mean	38.05%	59.01 million	1254.28 billion USD
p value	0.983	0.118	0.386
Considered to be close to a normal distribution?*	Yes	Yes	Yes

*If the p value is >0.05 (or any other error tolerance value chosen), then the data tested can be considered close to the normal distribution.

Table 6: The calculation results of the correlation test between the acceptance level, total population, and GDP.

Correlation between	Significance	Is the correlation considered significant?*	Pearson correlation coefficient
Public acceptance level and population	0.956	No	Insignificant
Public acceptance level and GDP	0.484	No	Insignificant
The population andGDP	0.001	Yes	0.608 (positive)

*If the significance is <0.05 (or any other error tolerance value chosen), then the data pair tested is considered to have a relationship (correlation).

Table 6 exhibits that the significant variable pairs were total population and GDP, with a correlation of 0.608 (positive). It means that the higher the population in a country with active nuclear power plants, the greater the tendency for the country to have a higher GDP. Unfortunately, it is not the focus of this study. Table 6 does not show variables correlating with the public acceptance level of nuclear power plants.

Analyses carried out geometrically revealed that countries with high population numbers and high GDP also had high public acceptance levels. The previous analysis resulted in this conclusion because it included data outliers, all three of which had a high acceptance level. Thus, it gives the impression that high population size and GDP also lead to higher public acceptance. It turns out that this view was not supported by analysis from a statistical point of view because it is not the case in general. The statistical analysis results indicate that other variables significantly influenced the public acceptance level more than the population or GDP.

These correlation test results have not completely invalidated the analysis results in the previous section. The correlation test was done by comparing the variables one by one, while the geometrical analysis results indicate a requirement for a large population size and a high GDP simultaneously. Therefore, an additional test was carried out using the ANOVA test to compare the data on the public acceptance level by category pairs in Figure 2. The pairs loaded the population size and GDP variables together. Table 7 displays the possible pairs of categories and the amount of data on these pairs.

ANOVA test is a statistical test that compares the mean data in specific groups. From Table 7, 16 groups representing each pair could be made, and then groups with more than one data were taken. ANOVA test can be done if the data in each group are considered not homogeneous (there are significant differences in each group). If the data are considered homogeneous or each group does not significantly differ, then the values cannot be compared, so the ANOVA test cannot be carried out. Data are called homogeneous if the p value of the homogeneity test results is higher than the error tolerance. Table 8 displays the ANOVA test results for the data in Table 6.

Table 7: Pair categories on the variable population size and GDP to test the relationship between the public acceptance level of the two variables simultaneously.

Pair no.	Population category	GDP category	Total data
1	Low	Low	10
2	Low	Medium	3
3	Low	High	0
4	Low	Very high	0
5	Medium	Low	2
6	Medium	Medium	3
7	Medium	High	2
8	Medium	Very high	0
9	High	Low	0
10	High	Medium	0
11	High	High	0
12	High	Very high	2
13	Very high	Low	0
14	Very high	Medium	1
15	Very high	High	3
16	Very high	Very high	3

Table 8 shows that the p value in the homogeneity test results table was less than the standard value for error tolerance (5%), so each group was considered a variation worthy of comparison. The mean column in Table 8 displays that the three groups with the largest mean in order were pairs 2, 16, and 8. Pair number 2 was ranked first because it listed the United Arab Emirates as having the highest public acceptance level, followed by the partner country. Pair number 16 represent a country with high population and GDP. Countries with a relatively small population but a high GDP could be represented by pair eight and get third. The pair of categories containing only one data could not be analyzed, so the pairs with the lowest mean acceptance level were pairs 5 and 15. Pair number 5 could represent countries with a low population and GDP while pairing number 15 represented countries with high population numbers but low GDP.

This result was equivalent to an analysis carried out geometrically, namely,

Table 8: ANOVA test results of acceptance level data based on grouping of total population and GDP.

Pair no.	Total data	Mean	The order of the mean	Description	Homogeneity significance
1	10	37.14	4	In the middle	
2	3	49.21	1	The highest	
5	2	34.00	7	The lowest	
7	3	36.14	6	Third lowest	0.049 (the order of the mean considered valid*)
8	2	42.42	3	Third highest	
15	3	37.00	5	Second lowest	
16	3	44.68	2	Second highest	

*The mean order is considered valid if the homogeneity significance is <0.05 (or any other error tolerance value chosen).

(a) Pair 2 received the highest score because the United Arab Emirates was included in the group. On the other hand, pair 1 with country characteristics was almost the same in terms of GDP, and the total population had a low mean acceptance level. These results are consistent with the geometrical data analysis results, in which countries with low populations and GDP had various views on nuclear energy use, ranging from low to very high.

(b) Pair 16, representing a country with a high population and GDP, had a better ranking than pairs 8 (large GDP, small population) or 15 (large population size, small GDP). It is consistent with the first result of geometrical data analysis, stating that a large population size needs to be accompanied by a high GDP to produce a society open to nuclear energy.

Pair 8 obtained a higher ranking than 15. It is also consistent with the geometrical data analysis results that those countries with a low population but high GDP tended to have a higher level of public acceptance than countries with a high population but low GDP.

4. Conclusion

There is a variation in the world average public acceptance level mentioned in many research publications, which shows that a standard or an acceptable level of acceptance (ALA) is fundamental. Through the valid standards specified in the ALA, it is hoped that the government and its stakeholders will pay more attention to public acceptance in planning the development of nuclear power plants, not only to fulfill normative requirements. This study was analyzed to measure the acceptable level of acceptance (ALA) of public acceptance toward nuclear power plants. This study also tested the stability of the ALA by comparing the GDP and the number of populations in countries with active NPP. The results of this study are given below.

The Acceptable Level of Acceptance (ALA) is between 51.5% and 63%. This grade is the best level of public acceptance, while the acceptance of 39.5% to 51.4% is still tolerably good. The other two grades are intolerable acceptance between 16% and 27.4% and moderate acceptance within the acceptable percentage of 27.5% to 39.5%. A moderate level of acceptance is concluded because of an uncategorized area of acceptance (UAA) due to the world's unexisting situation. This is an area of acceptance below 16% to 0% and higher than 63% to 100%.

Data Availability

The public acceptance data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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